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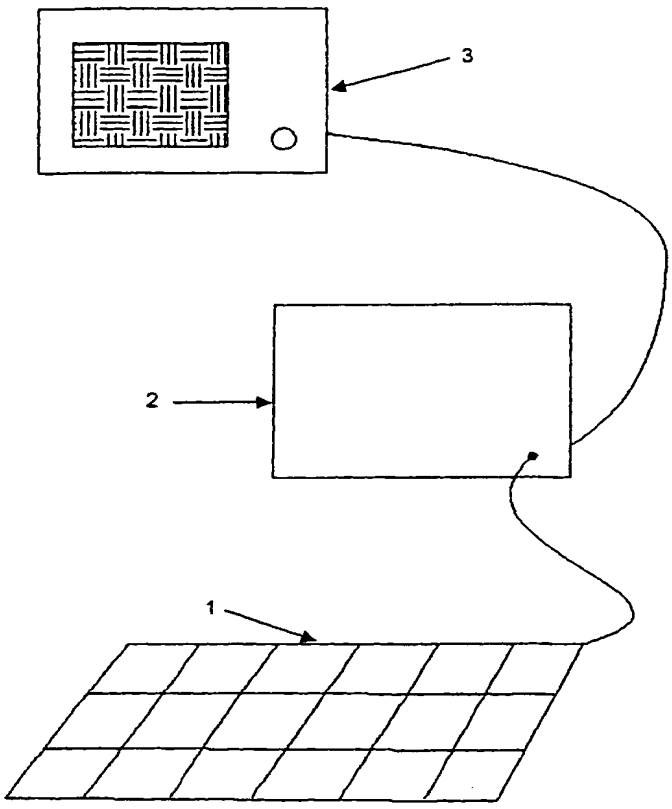

(57) Abstract: An interactive exercise device that indicates to the user what exercises to perform and collects the exercise performance data for analysis. In preferred embodiments the device will be portable and will have means to communicate information to the therapist.

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REHABILITATION DEVICE

The invention relates to exercise devices suitable for the rehabilitation of patients following traumatic joint injury or wound care but also for sports physiotherapy and general exercise. More specifically, the invention relates to an intelligent device that allows a selection of exercise programs to be monitored.

It is well known that muscles, bones and joints should be exercised to maintain strength. It is also known that fractures exposed to permissible weight bearing stress often heal more predictably and more rapidly than do fractures, which are not stressed at all. This is also believed true for connective tissue, such as ligaments and certain cartilage. Similarly the exercising of injured limbs has beneficial effects to the healing of the joint or muscle injury.

Currently the neuromuscular stage of rehabilitation is only addressed by one-to-one therapy treatment, which can be costly and is time consuming. Current treatment systems and devices are concerned with enhancing proprioception via skin receptors or by training balance alone in the therapist's clinic, this could include the wobble board and KAT system.

Previously proprioception was thought of as just balance, however surprisingly the devices of this invention show that the position and angle of the users limbs, and / or the kinesthesia of the users limbs may allow the therapists a better understanding of condition of the limb of the user. With regard to proprioceptive / neuromuscular rehabilitation this may allow the therapist a better understanding of the progression of a patients rehabilitation, whether the patient is progressing at the desired rate and whether the exercise program is suitable to the patient or if it is not to change the exercise program. Similarly this can offer benefits to the therapist working with sports men and women.

Previous physiotherapy equipment and treatment systems needed close supervision by the therapist to ensure that the

exercises were being carried out correctly and indeed to ensure that the patient was doing the exercises. The therapist, for the prior art rehabilitation systems had to be present when the user was being assessed. Usually the user, whether a patient or sports person, would have to travel to the therapist at a clinic to use the equipment, and to perform the exercises. Due to the time wasted between seeing one patient and the next this current system has the disadvantage of being a very ineffective use of the therapist time.

It was previously thought that the current system, of the patient always travelling to the therapist for their rehabilitation treatment could not be improved upon as the treatment system required large, sometimes heavy, expensive equipment which was not easily transportable and that the therapist would have to be present to monitor the exercise program.

The present invention is able to address these problems of the prior art by assimilating quantitative and qualitative data that can be communicated to the therapist for interpreting that will accurately indicate the progress of the patient performing the exercise programme. It was previously thought that the therapist would always have to be present at the time of the exercises as any data collected from the exercises could not interpreted to indicate the progress of the patient performing the exercise programme. Surprisingly we have found that this is not true.

It is an object of the present invention to address some of these before mentioned problems.

It is an object of the present invention to provide a proprioceptive and / or neuromuscular device that may monitor and record the user's performance.

It is an object of the present invention to provide a proprioceptive and / or neuromuscular device, which is portable.

According to the present invention there is provided an exercise device comprising; a lamina with a sensor for sensing

contact, and/or position on, or adjacent the lamina; and a processor for processing outputs from the contact, and or position sensor.

It is envisaged that with embodiments where a position sensor is used, the position sensor will be able to sense where a user's limb is adjacent to the lamina, even if not in contact with the lamina.

With embodiments of the invention that use a contact sensor, it is preferred that the contact sensor can also measure pressure or the force exerted on the lamina.

The term lamina is to include any substantially flat surface suitable to act as a target for the user's movement. This will include but not be limited to mats, rugs and the like.

Suitably the device of the present invention whether it comprises a contact sensor, a position sensor or both may also comprise a memory database to store the processed data generated so that this data can be downloaded or examined by the user or therapist at a later time.

Similarly the device of the present invention, whether it comprises a contact sensor, a position sensor or both also comprise a message conveyor to instruct the user to perform a predetermined exercise programme.

The device of the present invention may therefore comprise of a number of different added components. The present invention in a simple form may comprise of only one sensor, a contact sensor or a position sensor, and a processor. However the present invention may also include devices that have a contact sensor, a position sensor, a pressure sensor, a processor, a memory database and a message conveyor, or any combination thereof.

According to the present invention there is also provided an exercise device having;

a mat with pressure sensitive means for sensing contact on the mat and which is able to detect the position of contact on the mat;

and a control means connected with the pressure sensitive means for receiving outputs from the pressure sensitive means,

the control means further including programmed processing means for processing outputs from the pressure sensing means and memory means for retaining the processed data outputs from the pressure sensing means,

the control means further having means to instruct a user to perform a predetermined exercise program.

In favoured embodiments of the present invention the pressure sensitive means is also able to measure the amount of pressure or force applied to the mat. In some favoured embodiments of the present invention this is useful for determining the centre of gravity of the patient.

According to the present invention there further is provided an exercise device having;

a mat with pressure sensitive means for sensing contact on the mat and which is able to detect the position of contact on the mat, and the amount of pressure or force applied to the mat;

and a control means connected with the pressure sensitive means for receiving outputs from the pressure sensitive means;

the control means further including programmed processing means for processing outputs from the pressure sensing means and memory means for retaining the processed data outputs from the pressure sensing means;

the control means further having means to instruct a user to perform a predetermined exercise program.

It is envisaged that the present invention can be small enough to be easily transportable and therefore the exercise routine need not necessarily be performed at the therapist's clinic. The term therapist is used broadly to mean anyone overseeing the exercise programme or the rehabilitation of the user and this would include, but be limited to, physiotherapists and occupational-therapists.

Likewise the device may have means to convey instructions of the exercise programme to the user and has means to monitor and

record the users performance, it is again not necessary to use the device in the therapists clinic only.

Not being restricted to performing the exercises at the therapist's clinic has many benefits to both the user and the therapist.

The user can save considerable time by not having to visit the therapist as often and can more easily fit the required exercise program into his or hers daily routine. Being able to do the required exercises in private may also be a favourable consideration to some users and thus the user's compliance for doing the exercises may in fact increase when not in the presence of the therapist. This may be especially true when the device is for rehabilitation of elderly patients.

The therapist also saves considerable time as data from the device can be collated some time after the exercises have been done and can be sent to the therapists for analysing or can be down loaded to a data collecting station at a mutually convenient time. The therapists will however still be able to monitor closely the user's compliance of carrying out the exercise and to determine if the exercises are having the desired effect. The monitoring however can be done remotely and does not require the therapist to be present when the exercises are being performed. The therapist can alter the predetermined exercise program of the device in order to ensure that the user does have an exercise program suitable to their particular needs. Again this can be done remotely.

As individuals will perform the same exercise program in very different ways with differing degrees of abilities, especially regarding speed, force and accuracy, it is hard for a therapist to compare the progress of one user with another. For example a young sportsperson may well be able to perform a program of exercises faster than an elderly person that has been on the same program of exercises for a longer period of time than the sports person. Consequently for the therapist to measure the progress of the user it is not only how well the user performs the exercise on that particular

occasion, but how much of an improvement there is in performing the exercises from before. The present invention provides an easy means to store and analyse the users current and past exercise data to aid the therapist to monitor the progress of the user and therefore to be able to change the exercise program accordingly. There is therefore an opportunity for the user to have a speedier recovery, saving time and money for both the user and the therapist.

There is an increasing demand for quantitive (i.e. numerical) records of patients' rehabilitation to be available for the following purposes:

To make therapists accountable for their actions, for instance, for performance reviews or litigation cases.

For feedback to the surgeon/physician, for example for justification for or against further intervention.

For feedback for reimburser, for example to please insurance companies requiring proof that patients are complying with treatment.

For greater understanding of therapy and clinical research, i.e. optimisation, of treatments and presentation/publication of results.

For standardisation of treatment and common practices.

For overcoming prejudice views of therapists relating to rehabilitation.

The level of feedback to the therapist is determined by how the information will be used. Firstly, the data must be a substitute for clinical observations, which would normally be made by the therapist. The therapist must therefore have sufficient depth of information to allow clinical judgements to be made, and to progress the rehabilitation programme. For example, it is necessary for the therapist to know if the patient can bear weight through an operated knee. It is proposed that data supplied to the therapist will act not only as substitute clinical observations, but will also be capable of providing accurate measurements of how much weight is transferred through the knee, for what duration of time, over what range of motion and for how many repetitions of a specific movement/ exercise. An indication of proprioceptive integrity will also be given by the number of errors in performing a defined task. This data will

be available as raw numerical records, but may also be presented in a more accessible way, for example as a bar chart, histogram, graph or percentages. These presentation styles should be available to the user through a menu.

Examples of the information that could be available to the therapist (and/or user/patient) and the appropriate level at which it could be expressed are as follows:

Numeric values

Incidences - the number of times the device was used, repetitions of an exercise/movement, touchdowns during a single leg stance, steps taken (in a weight bearing exercise), movement limitation alerts.

Weight /force - weight /force transferred through a force plate sensor, standing or sitting.

Percentages

Numerical percentage - range of motion of a joint; performance of a repeated task.

Pie-chart -

Graph - Speed of movement of a limb, i.e. response times

Bar chart /histogram - Performance during a hopping exercise; response times

Stick figure diagram - To clarify the activity being carried out.

The lamina e.g. mat can be positioned to be suitable to detect contact with various limbs of the users body. Preferably it is envisaged that the user will have an exercise program that requires the user to move either a hand or foot, or any other suitable part of the body, to a desired position on the mat. These programs may

specify whether it is the left or right, hand or foot. For exercises requiring the user to move his foot or feet to desired positions on the lamina e.g. mat, the mat may preferably be positioned on the floor. Likewise for exercises designed to exercise mainly the lower body of the user, the lamina e.g. mat may be preferably placed on the floor. Where the exercises require the user to move the hand to various target positions, the lamina e.g. mat may suitably be placed on a table or on a wall or other vertical surface to allow easy positioning of the users hand on the lamina e.g. mat. Likewise for exercise programs that are designed to exercise mainly the upper body of the user, the lamina e.g. mat may also be suitably placed on a table or held vertically. Suitable means of attaching the lamina e.g. mat to a wall or vertical surface could be used to position the lamina e.g. mat. The lamina e.g. mat need not be restricted to substantially flat surfaces for it is envisaged that the lamina e.g. mat could be used on uneven surfaces in order to test a users balance and / or movement on an uneven surface. Typically the lamina e.g. mat could be used on stairs or on a wobble board. This is especially important for rehabilitation exercises where a patient may feel quite stable when on surfaces that are substantially even but not when on stairs or when on surfaces that are uneven. Suitable attachment means to attach the lamina e.g. mat, securely to the stairs would be preferably used in conjunction with the mat in order to ensure safe usage of the mat by the user.

The lamina e.g. mat may also have different textured surfaces for the user to perform the exercises on. This may be where there is different textured surfaces for different exercise programs or where the lamina e.g. mat is made up of different textured surfaces the same exercise program.

Likewise the lamina e.g. mat may also be used on soft surfaces. For example the lamina e.g. mat may be used on an exercise bouncer.

The lamina e.g. mat may be of any size or shape however it is envisaged that a mat of approximately 1m to 2 m by 1m to 2m would be preferable to allow for easy transportation of the device. It is

envisaged that a smaller lamina e.g. mat could be used for upper body exercises, for instance 1m by 1m, and a larger lamina e.g. mat, for instance 3m by 3m, for exercises directed at mainly the lower body. Typically the lamina e.g. mat would be 1m by 2m for exercises directed mainly for the upper body, and typically 2.5m by 1.5m for exercises directed mainly for the lower body. The particular mat need not be limited for any particular program of exercise and it is envisaged that the one mat could be used for exercises directed at both, the upper and lower, body of the user. When not being used, the lamina e.g. mat in some embodiments of the present invention may be easily rolled or folded to facilitate storage.

The lamina e.g. mat of the present invention may be formed from a number of parts, which together make up the device. In particular the number of contact, position and/or pressure sensors may change and there is not necessarily a set number of such sensors required. Suitably in preferred embodiments where the device of the invention is assembled from parts it is envisaged that the parts, for example the sensors, will join together easily and quickly to aid easy setting up of the device. In this way the number of sensors used for the exercise programme can be easily altered. In particular embodiments of the present invention the parts of the device may communicate with each other by radio means and therefore the parts making up the invention need not physically be in connected with each other.

The lamina e.g. mat can be made of any suitable material. Typically the lamina, e.g. mat, will be an elastic material or fabric. The mat may be a 3D fabric whereby the pressure sensitive means contain two rows of metallic strips that run perpendicular to each other and when pressure is applied to the mat the two rows of metallic strips come into contact with each other at the point of the applied pressure thereby indicating where the pressure on the mat has taken place.

Another embodiment of the present invention may contain a mat having a series of individual air pockets, which are the targets

for the user to hit. On applying pressure to the air pocket, air is pushed through a valve whereby the control means of the device can record which air pocket was hit and when.

Although such resistance type contact sensing means are cheap and readily available, these types of contact sensing means do suffer from the disadvantage that they contain moving parts which will wear out and not be robust.

Suitably the lamina e.g. mat of the present invention would use a contact sensing means using capacitance to detect contact. A capacitance sensing mat uses a single plate and senses the presence of the body or limb. The device has no moving parts and hence is may be very robust. Also with no moving parts the sensing element can be very flexible. The electronics detect a change in capacitance at the isolated pad, which can be any shape or size. Separate circuitry can be used for each pad although if a number of pads are to be used it is possible to multiplex the signals from the pads. The capacitance mat may be supplied with all its pads in place together or may be supplied in parts so that a number of different pads could be used and that the pads can be assembled together to form mats of different shapes.

The sensing pads of the capacitance sensing mat may each have an identifying electrical component such that the processor can identify each pad being used to make up the mat. Therefore when the pads are put together in the correct predetermined order the correct data processing can take place. In this way the processor can identify if the exercise was performed correctly or not.

It may be a requirement that for the desired programme of exercises to be performed correctly that the pads are put together in particular manner to form a mat of a particular shape. Such instructions would have to be conveyed to the user or therapist before performing the exercise. The sensor that make up the lamina e.g. mat may communicate with each other and the processor by radio means such that the sensors do not have to be

physically connected to each other or to the sensor, by cables, wires and the like.

Using capacitance sensors in this way, as for large foot size pads, is new, previously only very small capacitance sensors have been used and it was previously thought that the capacitance sensors had to be small due to the possibility of electronic interference. The present invention has now demonstrated that large capacitance sensors can be used to accurately detect contact without electronic interference, even when a user of the mat is moving above the mat surface as when performing the exercise programme. The present invention has also found that the use of screens around the sensor plate further reduces electronic interference, enabling the capacitance sensors to be successfully used as large contact sensors for the performing exercises.

The mat of the present invention may also measure the amount of pressure applied to various points of the mat, not just if contact is made. This may provide useful information to the therapist in order for the therapist to assess if the exercise program is, among other things, helping the user.

The means to measure the pressure applied to the mat may be any means suitable for such purpose and there are currently a number of different methods known for measuring pressure and force. In the majority of cases a force reading is taken over a given cross-sectional area and hence is recording a pressure.

The measurement of pressure in a clinical environment is normally required in order to determine the patient's load bearing.

One suitable means may be where the mat has a flexible fluid chamber, suitably shaped to cover the area of the mat and having first and second opposed walls. The flexible fluid chamber would be without internal elements that would hold the first and second walls apart, but would possibly be subdivided into smaller fluid filled chambers. The chamber would also have means for providing a fluid communication between said chamber and a pressure, sensing

device. When pressure is exerted on the chamber, for instance, when a foot is lowered onto the mat the fluid in the chamber would be forced towards the pressure sensitive device, which would be able to measure the force and this force could be calibrated to measure the force on the mat.

An alternative method is to incorporate a force/pressure sensing mechanism within the contact, sensing mat. The force sensing means can take the form of a force, sensing resistor (FSR) as supplied by Steadlands International Marketing Ltd., Northumberland, UK. The FSR consists of two polymer sheets laminated together. One sheet is coated with interdigitating electrodes top a greater or lesser degree. By measuring the resistance the force can be recorded. The sensor takes measurements in the first 20 seconds of loading and then an average of these readings is taken.

One option for a single, one-off measurement is to use a pressure-indicating film, as supplied by Fuji (Pressure (R)). The film records the pressure distribution according to colours; the more intense the colour, the greater the pressure. The films are single use and would be mounted on the reverse side of the mat. A colour scale would be provided to the clinician. The therapist will ask the patient to stand on two tiles of the mat and stand normally with equal load through both limbs. Once the patient moves off the tiles, the therapist can compare the pressures recorded for the involved and uninvolved limbs by eye. The mechanics of the exercises, are qualitative and this is an improvement on current practice where a patient is asked to stand on a therapists hand in order for the therapist to judge the loading.

Preferably the mat will have markings to act as specific targets for the user to make contact with the mat when directed to do so for the particular exercise program. This could be simply a series of labelled or indexed grids on the mat. The grids on the mat could be of different sizes and therefore suitable for a wider range of exercise programs. Typically when different size grids are used on the one mat the grids will be coloured coded in order to allow easy visual

differentiation between the grids. Typically the grid spacing will enable desired targets to be large enough for the users hand or foot to be placed substantially over the target area.

Other markings could simply be shapes, numbers, letters or pictures on the surface of the mat.

With some embodiments of the present invention the pressure sensitive mat may not necessarily have the marking directly on the mat but the mat could be used in conjunction with a target cover that is to be placed over the pressure sensitive mat. The target cover may be like a sheath to cover all or part of the mat and it is the target cover that has the markings to act as targets for the user.

Typically the grid spacing will enable desired target areas to be large enough for the user's hand or foot, or other body limb, to be placed substantially over the target area.

The mat may even contain lights on the surface of the mat in embodiments of the present invention where the lights themselves are the target for which the user should place their hand or foot on when that particular light lights up. The lights would suitably be protected from the physical contact of the user putting pressure on the surface of the mat. It would also be preferable with this embodiment of the present invention if the lights could be contained within the substantially flat surface of the mat or cover target so that the surface is still substantially flat. Having the surface substantially flat is important where the user is walking on the mat and may be tripped by the lights if the lights projected from the surface.

Typically the control means will be able to collect and store the data in order to be able to later download the collected data. The downloading of the collected data may be done by the therapist, either at the clinic or elsewhere or the data could be downloaded by the user and sent to the therapist for analysing. It is possible, using suitable means that the collected data could be sent to the therapist by telephone, e.g. e-mail, or radio. It is even possible that the collected data could be sent to a collecting station near to the

therapist or at the clinic to enable the therapist to analyse the data when required.

The predetermined exercise program of the device may be pre-programmed into the device by the therapist. There is no limitation to what exercise programs could be programmed into the device, in order for the user to carry out the exercise program. The therapist would preferably choose an exercise program that would be challenging to the user but still within their capabilities. The exercise programs may consist entirely of simple commands, for instance to move the left foot to grid H or to move the right hand to square 5, if such grid or square locations were represented on the mat. The commands may be any number of different command including commands to ask the user to jump, hop, hit, kick, run or push.

Common exercises for the user to perform with the present invention may be single leg stances. These are relatively static exercises, which are widely used in the early stages of rehabilitation to test and improve proprioceptive ability. The user would stand in a specified position on the mat and may be requested to lift their uninvolved leg so that they are standing on their injured leg. The mat will record how long the user can maintain this position or how many touchdowns the user made in a set time.

Another common exercise that may be used with the present invention is lunges. Lunges are a widely used exercise that may vary from easy forward lunges close to the starting position to difficult long lunges diagonally across the body. Each lunge is done from the same starting position and this starting position should be returned to before the exercises can progress.

A further exercise, which may be performed with the present invention are various hopping patterns. Perhaps used in the later stages of rehabilitation, the mat may provide targets for the patient to hop to. This exercise incorporates general agility, response time, and perturbation of balance due to rapid changes of direction. The

device may record where the errors occur, how many errors, how the errors occur, how quickly a pattern can be completed.

Further exercises which may be performed on the mat of the present invention further include but are not limited to, front and side lunges; stork stances; Romberg test; side step over perturbation training; plyometric training and stretching drills; and running.

The instructions or commands of what movement the user is required to do can be conveyed to the user by any suitable means. The means to convey instructions or commands to the user need not necessarily be attached to the control unit as the means to convey instructions or commands to the user may be in wireless communication with it. This may be by instructions on a TV or LCD screen that the user can look at whilst performing the exercise programme. The display on the screen may be by any suitable means but would typically be written instructions or a graphic display of what the instructions are. The instructions may also be conveyed to the user by other visual means for example when lights are used within the mat to move to the light, which is switched on or off as the case may be. Additionally the device may incorporate a light projecting means on to the mat where the user must move to where the light projection falls onto the mat. The instructions however could be by simple audio means i.e. audio- tape or digitised voice. In the simplest of embodiments of the present invention the instructions to the user in order to perform the exercise program may be written on a sheet of paper. Once the device has indicated to the user to start the exercises, for instance, this may be to show that the control unit is switched on and is ready to monitor and record the exercises. Suitably, the user may perform the exercises as written on the sheet of paper.

Besides instructing the user to what exercises to do the present invention may have means to inform the user if the exercises was completed correctly or not. Conveying the message or information back to the user may be by any suitable means, for instance, by light or sound.

In order to have the user feedback whether the user was performing the exercises correctly or not, the feedback system may have the following stages:

Start - to indicate correct neutral or starting position before beginning an exercise but also may be to indicate neutral position at the end of an exercise. This should be neutral sound e.g. buzz, or light e.g. white light. This would give the patient confidence that they were beginning the exercise correctly every time. The correct starting position would quickly become familiar giving a sense of control, self-direction and ownership of their rehabilitation.

Hit/Success - this indicates that the prescribed instruction/exercise has been successfully performed. It should be indicated by a positive sound e.g. bell or green light. This should reinforce the patient's confidence and hopefully provide motivation.

Improvement indicates that the prescribed instruction/exercise has been successfully performed with an improvement on the previous recorded attempt. It could be repeating bell sound or flashing green light. This is designed to motivate the user.

Miss - indicates that the instruction/exercise has not been performed correctly. It could be a negative sound e.g. low pitch buzz, or red light. It should be followed by a restart command and the Start indication of the correct neutral starting position. The purpose of this would be to prevent incorrect movements, which might be deleterious and thus give confidence to the user.

Alert - this would be used for users who are required to learn limitations to their movements. Examples are learning correct posture for back patients, learning correct lifting technique, preventing uneven weight-bearing, avoiding hip dislocation after hip replacement, and avoiding over-extension following TKR. The purpose would be to indicate to the user that they were approaching their maximum permitted ROM and therefore prevent potentially deleterious movements. The indicator could be an amber light, a

low level beep or a vibration. This would prevent re-injury, accelerate healing and give the patient a sense of control and confidence.

Performance level - for users who are highly motivated e.g. athletes and sports people, and who are determined to reach a high level of fitness, it is possible the hits, misses and improvements could be indicated as a bar chart or percentage. The number of repetitions of an activity could, also be displayed by a simple counter. This would provide motivation as well as a sense of control.

As the instructions to the user may also be in the form of lights or sounds, the present invention should be designed so that command signals are not confused with feedback indicators.

In order to reduce the number of visits to the therapist required by a user when the device of the present invention is for home use, the device of the present invention will suitability also have means to convey information regarding the exercises performed by the user to the therapist. In this way the physiotherapist will be able to monitor the progress of the user without needing to actually see the user. It is envisaged that any suitable means to convey this information from the device to the physiotherapist may be used. These means may include a smart card, which would collect the exercise performance data from the device and then this smart card could be taken or sent to the therapist. The device may also have a telephone modem in order to send the data to the therapist's office. This may be at set times picked by the programmed device itself or when requested by the user or therapist.

The device of the present invention could also be used in the therapists clinic, or in the presence of the therapist, and this may enable the therapist to monitor the user more quickly than in the past or more efficiently than in the past.

The device may already have programmed into it an alerting system which when the exercises have been performed a set

number of times, at a set efficiency, the user, or therapist, is alerted to download the information.

In the simplest form, the data may be printed out for sending to the therapist or the device itself may be returned to the therapist.

The invention further provides a method of manufacturing an exercise device comprising the step of connecting;

a lamina with a contact and /or position sensor; with a processor for processing outputs from the contact and/or position sensor.

The invention further provides a method of manufacturing an exercise device comprising the step of connecting;

a mat with pressure sensitive means for sensing contact on the mat and which is able to detect the position of contact on the mat;

and a control means interconnected with the pressure sensitive means for receiving outputs from the pressure sensitive means;

the control means further including programmed processing means for processing outputs from the pressure sensing means and memory means for retaining the processed data outputs from the pressure sensing means;

the control means further having means to instruct a user to perform a predetermined exercise program.

Further according to the present invention there is provided a method of manufacture of an exercise device comprising the step of connecting;

a mat with pressure sensitive means for sensing contact on the mat and which is able to detect the position of contact on the mat, and which pressure sensitive means is able to detect the amount of pressure or force applied to the mat;

and a control means interconnected with the pressure sensitive means for receiving outputs from the pressure sensitive means;

the control means further including programmed processing means for processing outputs from the pressure sensing means and

memory means for retaining the processed data outputs from the pressure sensing means;

the control means further having means to instruct a user to perform a predetermined exercise program.

The invention will now be further described by way of example only with reference to the drawings, which are:

Fig. 1 shows a device according to a first embodiment of the invention.

Fig. 2 shows a mat according to a second embodiment of the invention.

Fig. 3 shows a capacitance sensing mat according to a third embodiment to the invention.

Fig. 4 shows a first layer of a pad of the mat shown in Fig. 3.

Fig. 5 shows a second layer of one pad of the mat shown in Fig. 3, to be positioned under the first layer.

Fig. 6 shows a third layer of one pad of the mat shown in Fig. 3, to be positioned under the second layer.

Fig. 7 shows a fourth layer of one pad of the mat shown in Fig. 3, to be positioned under the third layer.

Fig. 8 shows a top layer of one pad of the mat shown in Fig. 3, to overlay the first layer.

Fig. 9 shows a perspective view of two interlocking portions of a mat according to one embodiment of the invention.

Fig. 10 shows a perspective view of two interlocking portions of a mat according to a further embodiment of the present invention.

Fig. 11 shows a perspective view of two interlocking portions of a mat of a further embodiment of the present invention.

Fig. 1 shows a first embodiment of the invention whereby a pressure sensitive mat (1) is attached to a control unit (2). The control unit (2) is also connected to an audio microprocessor (3) that is able to give audio instructions of the predetermined exercise program to the user of the device.

Fig 2 depicts a pressure sensitive mat (21) for use in accordance with a second embodiment of the present invention. The mat (1) has a target grid on its upper surface.

Fig. 3 depicts a pressure sensitive mat (4) for use in accordance with the present invention whereby the pressure sensitive mat (4) is a capacitance sensing mat. A sensor (not shown), for each grid space, positioned near the top surface of the mat can measure the capacitance between the body part or limb of the user near the grid space and an earth screen positioned on the other side of the sensor from the users body part or limb.

It is envisaged for simplicity that the capacitance sensing mat need only measure a change in capacitance to enable detection if the user is present at a particular grid or not. It is however possible that the capacitance sensing may be more sophisticated and could measure actual capacitance values. The capacitance values can be used to indicate how close the limb or object is to the capacitance sensing mat.

Figures 4 to 8 show various layers of one grid portion of the mat according to the mat shown in Fig. 3, and are described further in the Examples hereinafter.

The two interlocking portions of the mat shown in Figure 9 interlock via a tongue and groove joint that is fixed on a cylindrical barrel to allow rotation and movement in the joint to allow ease of connecting the interlocking portions and so that the mat need not be strictly horizontal The internal circuit is connected to a central point

on a connector part of the interlocking portion via a flexible conductive strip, which allows movement in the joint without comprising data transmission.

Figure 10 shows two interlocking portions of a mat of the present invention that lock together by a finger joint mechanism. The conductive element is situated on the outside of one of the finger joints, which may slot into the second portion of one of the joints of a neighbouring interlocking portion. The contact between the interlocking portions may have two hundred and seventy degrees in coverage it allows complete rotation and movement in the joint, maintaining information transfer between the portions.

Figure 11 shows two interlocking portions of a mat according to the present invention that may join together by a snap-fit ball and socket joint. The two portions simply pop together forming a link. The joint is coated with an appropriate conductor over the surface to allow electrical transmission of data and power. As the joint is a ball and socket joint it accommodates any unpredictable movement aiding the transmission of data.

Examples of the manufacture and use of the invention are described below:-

Example 1

An exercise device having a 3D pressure sensitive mat with two rows of parallel metallic strips, the strips in each row running substantially perpendicular to each other along the top and bottom surfaces which when pressure is exerted on the mat, contact between the metallic strips is made indicating to the control unit where on the mat the contact was made. The position and time intervals between contact on the surface of the mat is monitored. The mat is positioned on the floor and the user is instructed audibly from a microprocessor to perform particular exercises by placing the left foot or right foot on various positions on the mat. The grid measures approximately from 1.5m by 1.5m and has two colour-coded grids. A solid line blue coloured grid whereby the grid forms

squares with sides of 15 cm in length and these squares are evenly divided into four by a red coloured broken line grid. The blue coloured grid is labelled in the centre of the squares by blue numbering one to one hundred. The control device is pre-programmed to instruct the user to move his left foot or right foot to various positions by the audio microprocessor. This information is collected and stored in the control means. After performance of the exercise program the data collected is sent by telephone via a modem to a central data collecting station at the therapists clinic for the therapist to analyse the data at a later time. The therapist can therefore monitor compliance by the patient and the accuracy and speed of carrying out the programmed exercises. In this way the therapist saves considerable time in monitoring the user but can still monitor the benefits of performing the exercises.

Example 2

An exercise device comprising, a rubber pressure sensitive mat hanging from a door. The mat is hung from the door by a light plastic clip that attaches to the mat and hangs over the top of the door. The door is closed to firmly hold the mat in a stable position. The pressure sensitive means of the mat consists of two rows of parallel metallic strips, the strips in each row running perpendicular to each other. When pressure is applied to the mat the metallic strips running perpendicular to each other make contact and the control unit attached to the pressure sensitive device, is able to collect data concerning when the mat had pressure put on it and at what position on the mat. The mat is approximately 1m by 1m with different coloured circles measuring 15 cm in diameter on the outer facing surface of the mat. The pressure sensitive means is connected to a control unit, which is itself connected to a coloured TV via the aerial socket of the TV. The TV is placed in view of the user when the user is positioned next to the mat. The control unit conveys instructions to the user via the TV screen as the TV screen displays the particular colour of circle which the user is instructed to move his hands to in accordance with the predetermined exercise program, programmed by the therapist beforehand. The compliance of the user and the accuracy and speed at which the user completed

the exercise program is monitored. This data is collected and stored by the control unit until downloaded by the therapist to a central data collecting station by telephone via a modem.

Example 3

Similar to Example 2 apart from the user is requested to move the left elbow to the target positions.

Example 4

Exercises are executed on a mat consisting of 12 numbered pads arranged in a 4 X 3 (four pads by three pads) arrangement as shown in Figure 3. Each pad measures 300 mm by 300 mm and has individual electronics connected to a laptop personal computer (PC) that are able to detect when contact with the individual pads are made.

The patient / therapist interface and data analysis is done by the PC using the software Labview v5.1.

The pads are made up of a number of layers. The first layer (Figure 4) has a centrally positioned square sensor (5) measuring 170 mm x 170 mm and a screen (6) 205 mm by 205 mm surrounding the sensor but not touching it. The screen (6) is connected to the earth screen (7) of the third layer (Figure 6) and acts to prevent electrical interference from for example other sensors.

The second layer (Figure 5) has a guard plate (8) the same size as the sensor and positioned directly underneath the sensor.

The third layer (Figure 6) as mentioned has the Earth Screen (7), which is larger than the sensor (5) and guard plate (8) and measures 205 mm by 205 mm. This acts to prevent electrical interference with sensor for example from the floor direction.

The fourth layer (Figure 7) is a backing layer of vinyl floor covering that is 1.5 mm thick.

A top layer (Figure8) consisting of a calico sheet (a woven cotton fabric) is stuck to the top layer to prevent abrasion of the electrodes and to be a fixture for the target numbers which are fixed to the top layer using iron-on ink jet film.

The above described layers make up a capacitance contact sensor such that the body part or limb completes the capacitor and the sensor detects the electrical difference between the guard plate and the body part of the user. The capacitance sensor can therefore detect the presence or absence of contact of the user. In sophisticated embodiments of the invention the capacitance sensor will be able to give different reading values of the capacitance detected.

The screen surrounding the sensor acts to protect the sensor against electronic interference or from measuring the capacitance between the guard plate and the body part of the user when the user is only near to this particular pad i.e. when the user is standing on an adjacent pad or simply moving over the pad.

The layers are stuck together using an adhesive.

The exercise file or computer program is a text file and is loaded into the PC, the computer program of this example is of an exercise programme for the legs.

The programme is set to ask if the user will move one or both feet, by asking if there is a base square. This would be the square from which the patent does not move his good leg during exercise. If both feet are to be moved then there is no base square and "0" is entered. The mat programme behaviour can be modified by adding single letters after the mat number e.g. a "b" indicates that the mat is a base square and is only valid on the first line of the exercise file, a "c" indicates that the patient must move to the mat correctly before the next target is displayed.

For a lunge exercise for a patient exercising his left leg, with his right leg being healthy and not requiring exercising the programme may run.

Exercise File	What the patient does
11b	Place right foot on the base square (square 11)
10c	Place left foot on square 10
5	Move left foot to square 5, then back to square 10
10c	Move left foot to square 4, then back to square 10

Features of the software include:

1) The right foot moving on or off the base square is ignored, and does not count as patient movement. Therefore, accidental foot bounces on the base square do not change the target.

2) Just one attempt at the movement away from square 10 is allowed. Thus, if the patient fails to lunge the further squares (e.g. squares 4 or 8), the failure is recorded in the exercise data log and the target square changes to square 10.

3) The return movement back to square 10 must be correctly completed, and the target will not change until the left foot is standing on square 10 alone.

All failed attempts to reach square 10, to accidentally landing on a wrong square or to dragging the left foot over the mat on the way back from the further squares are still recorded in the log.

The results

The filename of the results, is chosen by the software program, and is the exercise name followed by a number, ending with "txt". Thus "lunge017.txt" contains results referring to the seventeenth time that the lunge exercise programme has been carried out. The files can be read by almost any word processor.

A typical lunge results file is as in this example:

Start date: 26 January 2000
Start time 14:33:22
Exercise: LUNGE

Target: 10	Hit: 10		Correct
Target: 06	Hit: 10	0.935 sec	Correct
Target: 10	Hit: 10	0.566 sec	Correct
Target: 07	Hit: 07	0.926 sec	Correct
Target: 10	Hit: 10	0.516 sec	Correct
Target: 09	Hit: 09	1.182 sec	Correct
Target: 10	Hit: 10	0.515 sec	Correct
Target: 05	Hit: 06	1.399 sec	
Target: 10	Hit: 10	1.028 sec	Correct
Target: 02	Hit: 06	1.233 sec	Correct
Target: 10	Hit: 10	0.830 sec	Correct
Target: 03	Hit: 03 07	1.289 sec	
Target: 10	Hit: 10	0.921 sec	Correct
Target: 01	Hit: 06	3.493 sec	
Target: 10	Hit: 10	4.063 sec	Correct
Target: 08	Hit: 07	2.765 sec	
Target: 10	Hit: 02	5.300 sec	
	Hit: 06 10	6.322 sec	
	Hit: 10	2.000 sec	Correct
Target: 04	Hit: 07	1.842 sec	
Target: 10	Hit: 06	1.388 sec	
	Hit: 10	3.592 sec	Correct

Example 5

Hop exercise

A mat and apparatus as described in example 4 is used to perform the hop exercises. These exercises can be used to exercise either leg, however the exercise file may need to be altered so that the patient makes more hops in the directions recommended by the therapist.

What the patient does:	The exercise file:
(There is no base square)	0
Place right foot on the starting square (square 1)	1c
Hop to square 6	6c
Hop to square 7	7c
Hop to square 10	10c
etc.	etc.

Features of the software includes:

1) Correct movements are required for all hopping movements, regardless of the number of extra hops put in by the patient.

2) Hopping on the same square, for example to regain balance, is detected but the target does not change.

3) Stepping from square to square would not be spotted until contact on two non-adjacent squares was detected. Both contacts would be recorded and entered in the results file.

Similar results to Example 4 could be obtained.

Example 6

A mat as described in example 4 was used for balance type exercises. The object of the balance exercise file in this instance is to test the stability and strength of the patient's right leg. In

principle, the same exercise could test the left leg by standing on the mat and facing the other way.

What the patient does:	The exercise file:
The user stands, eyes closed on one foot on the base square (Square 1) He is timed until he puts his other foot down, or takes his foot off the base square. This is repeated several times.	7b 6c 0t 2c 6c 0t etc.

Features of the software include:

1) Once the patient or therapist has started the computer, all commands are made through the mat.

2) The difficulty with timing balance is that the patient may be standing on one foot while walking over the mat or getting himself into position. Thus, it is of no use merely to detect when just one foot is touching the mat.

3) The mat time is primed as follows. The patient puts his right foot on the base square (square 1) while his left foot is not on square 6. Without moving his right foot, he places his left foot on square 6. The software will start timing his balance duration as soon as he lifts his left foot. The timer will stop as soon as he puts his foot down or leaves (falls off) the base square.

4) Optionally, when the patient is ready to repeat the balance exercise, he can move a foot to square 2 so that the priming sequence can start. This may be desirable so that the patient is forced to compose himself before repeating the exercise.

5) Should the patient start the priming sequence but then want to stop, he touches any other square or simply walks off the mat.

Typically the results may be, as in this example:

Start date: 26 January 2000
Start time: 14:51:54

Exercise: STANCE

	Hit:		09	
	Hit:		07	
	Hit:	06	07	
5	Hit:	05	07	0.303 sec
	Hit:		05	
	Hit:			
	Hit:		06	
	Hit:	06	07	
10	Hit:		07	
	Hit:	06	07	
	Hit:		07	
	Hit:	05	07	8.224 sec
	Hit:		07	
15	Hit:	06	07	
	Hit:		07	
	Hit:			4.112 sec
	Hit:		06	
	Hit:	07	09	
20	Hit:	06	07	
	Hit:		07	
	Hit:			9.724 sec
	Hit:		11	
	Hit:		07	
25	Hit:	06	07	
	Hit:		07	
	Hit:	07	10	2.631 sec
	Hit:		07	
	Hit:	07	10	
30	Hit:		07	
	Hit:	06	07	
	Hit:		07	
	Hit:	06	07	0.403 sec
	Hit:		07	

Exercise completed

Finish time 14:54:49

Number of touchdowns: 6

Duration: 0 minutes 25.4 seconds

There is no target in a balance exercise, and the times are only recorded when the patient is balancing. The results file ends with the number of touchdowns and the total balancing duration. More detailed statistics could be added if desired.

CLAIMS

1. An exercise device comprising; a lamina with a sensor for sensing contact, and/or position on, or adjacent the lamina; and a processor for processing outputs from the contact and or position sensor.

2. An exercise device as claimed in claim 1 in which further comprises a pressure sensor.

3. An exercise device as claimed in claim 1 in which the contact sensor is also a pressure sensor.

4. An exercise device as claimed in any one of claims 1 to 3 in which further comprises a memory database.

5. An exercise device as claimed in any one of claims 1, to 4 in which further comprises a message conveyor to instruct the user.

6. An exercise device as claimed in claim 2 or 3 in which the pressure sensor is able to measure the force or pressure exerted on the lamina.

7. An exercise device as claimed in any preceding claim in which the mat comprises one or more labelled target positions.

8. An exercise device as claimed in claim 7 in which the labelled target portions are identified by a grid.

9. An exercise device as claimed in claim 1 in which the contact sensor is a capacitance contact sensor.

10. An exercise device as claimed in claim 9 in which the capacitance contact sensor has a screen partially around the sensor element in order to protect the sensor from stray electric elements.

11. An exercise device as claimed in claim 4 in which the memory database is stored on a smart card.

12. An exercise device as claimed in claim 5 in which the information to be conveyed by the message conveyer is stored in a smart card.

13. An exercise device as claimed in any preceding claim in which further comprises a modem to send data from the exercise device to a data-collecting unit.

14. An exercise device as claimed in any preceding claim in which the exercise device is portable.

15. An exercise device as claimed in claim 5 or 12 in which the message conveyor to instruct the user is a TV or LCD screen or set of lights.

16. An exercise device as claimed in claim 1 to 6 in which the lamina is a mat.

17. A method of manufacturing an exercise device comprising the step of connecting;
a lamina with a contact and /or position sensor; with a processor for processing outputs from the contact and/or position sensor.

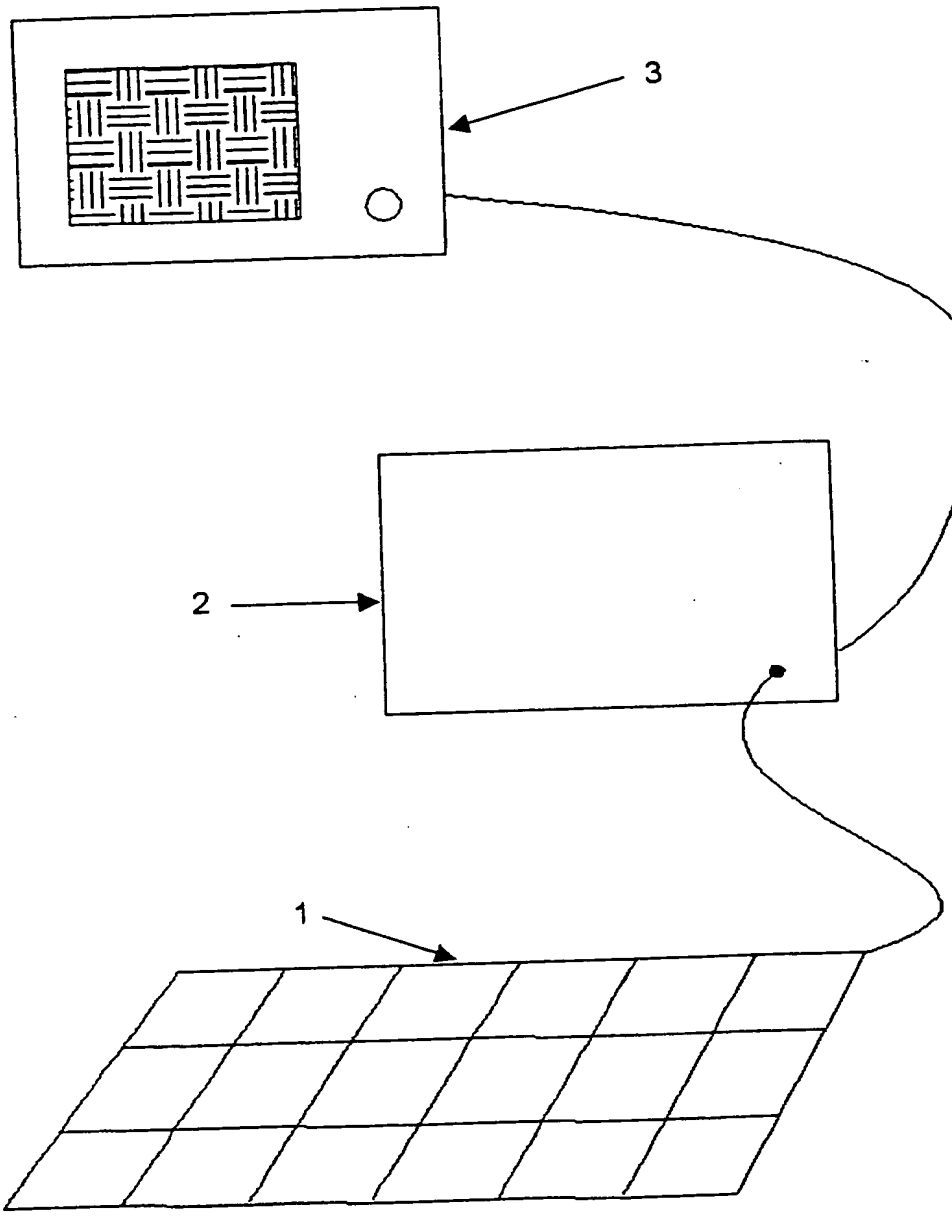

Fig. 1

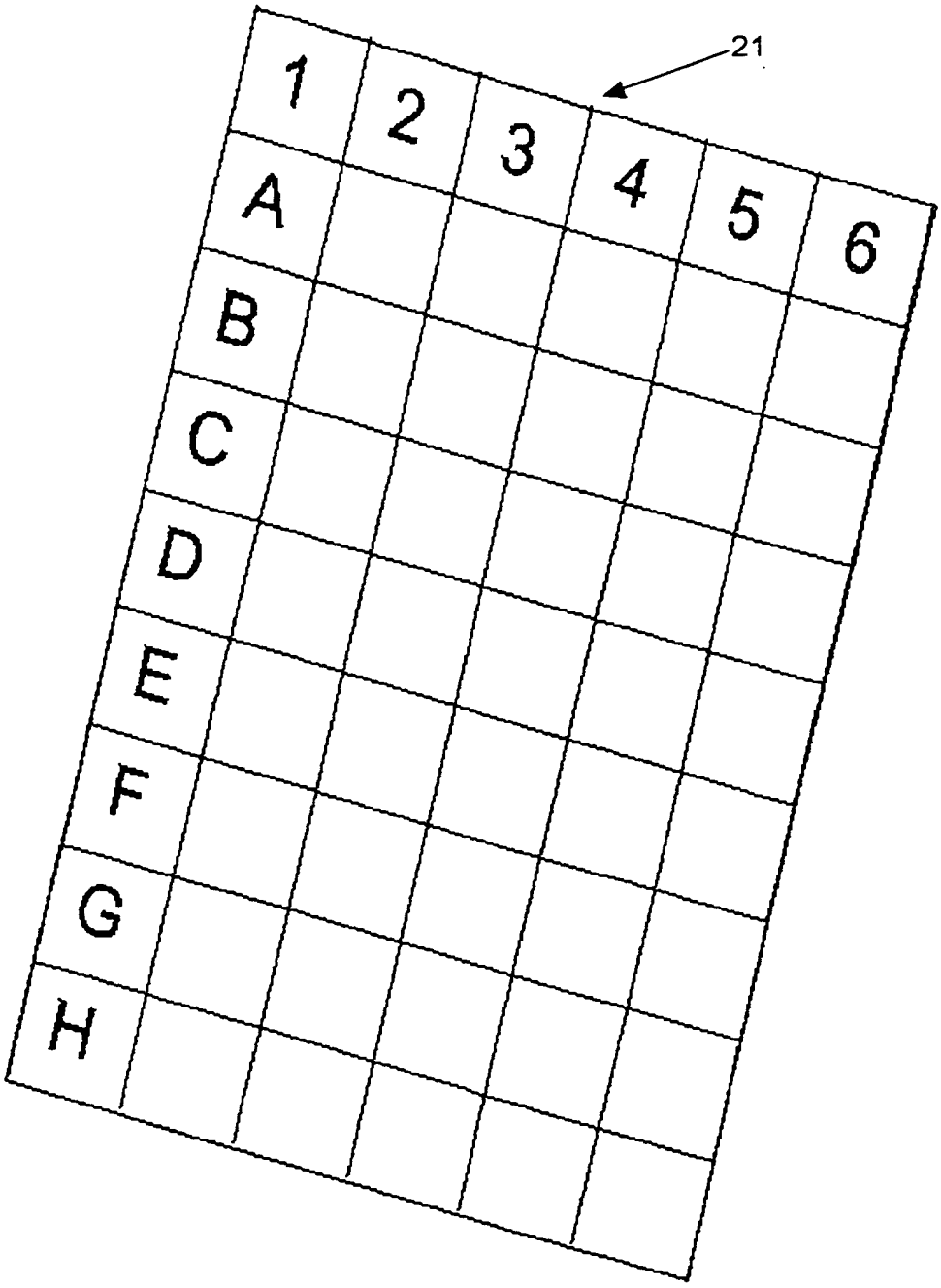

Fig. 2

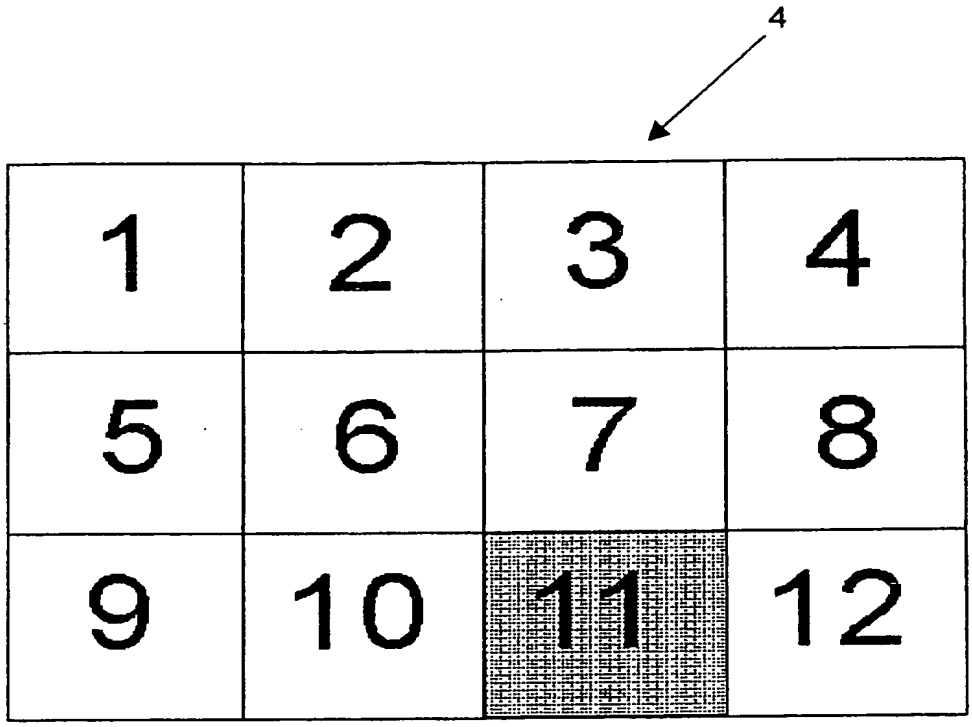

Fig. 3

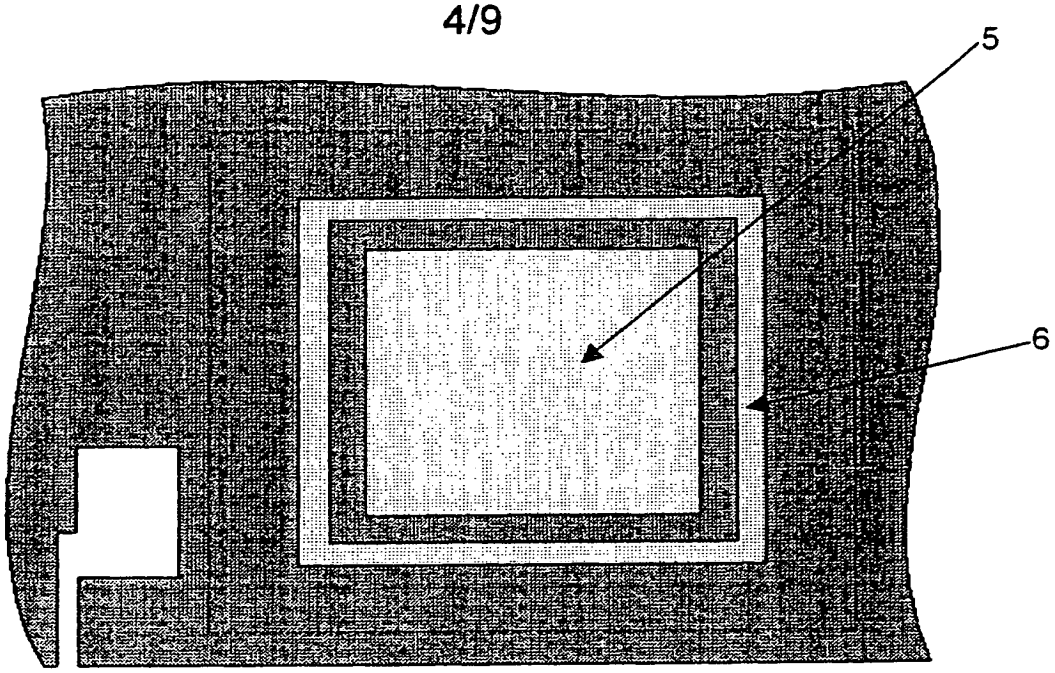

Fig. 4

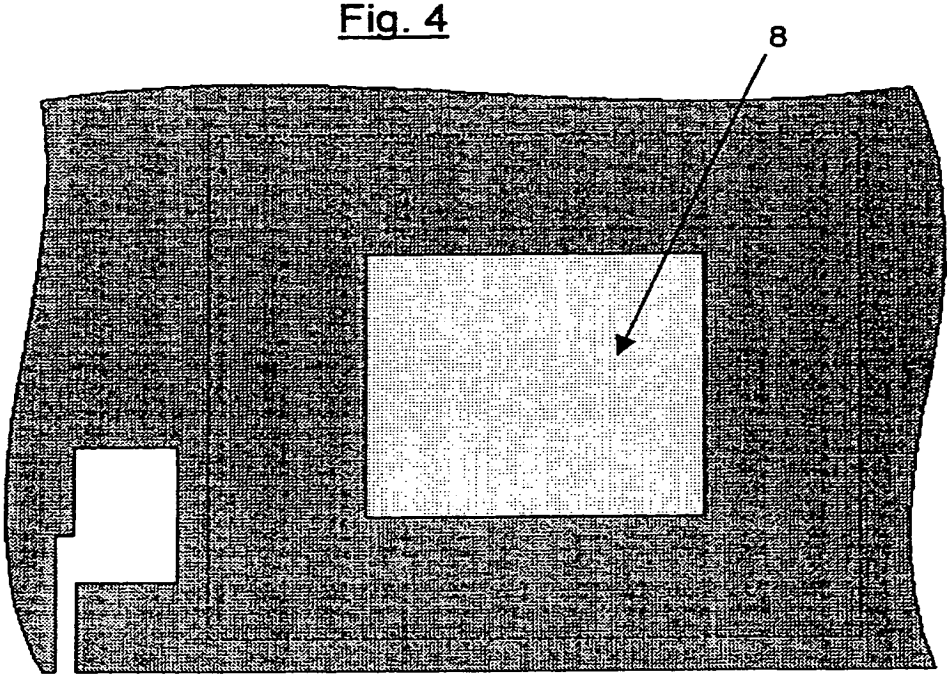

Fig. 5

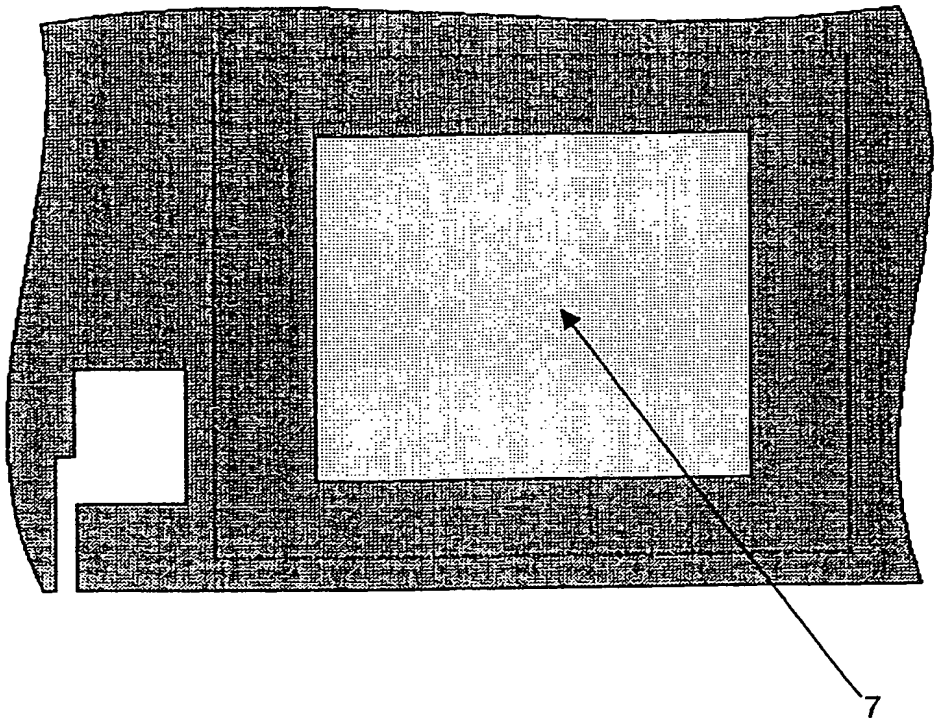

Fig. 6

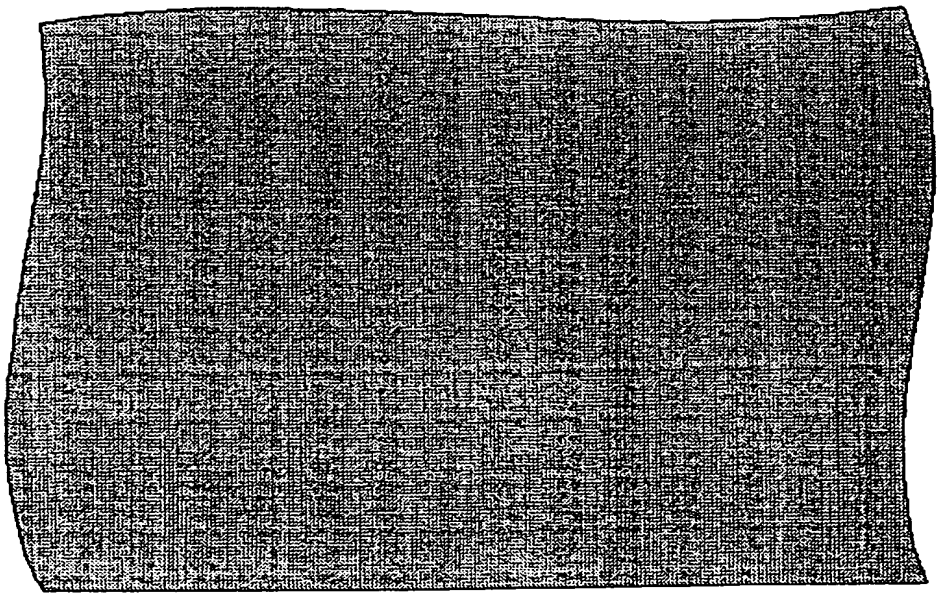

Fig. 7

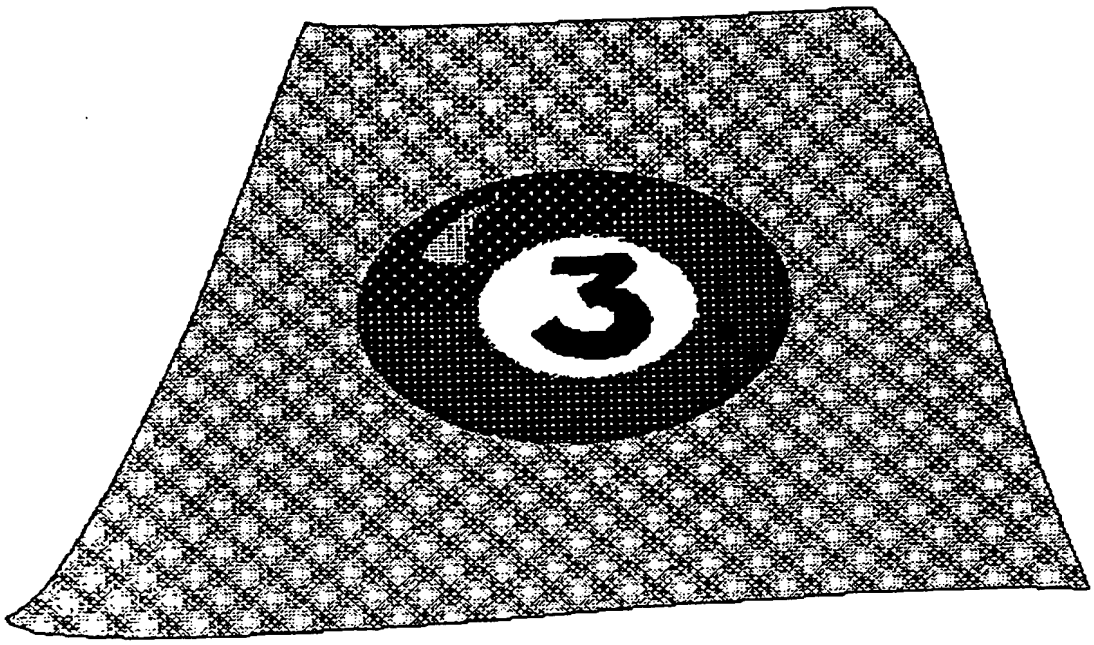

Fig. 8

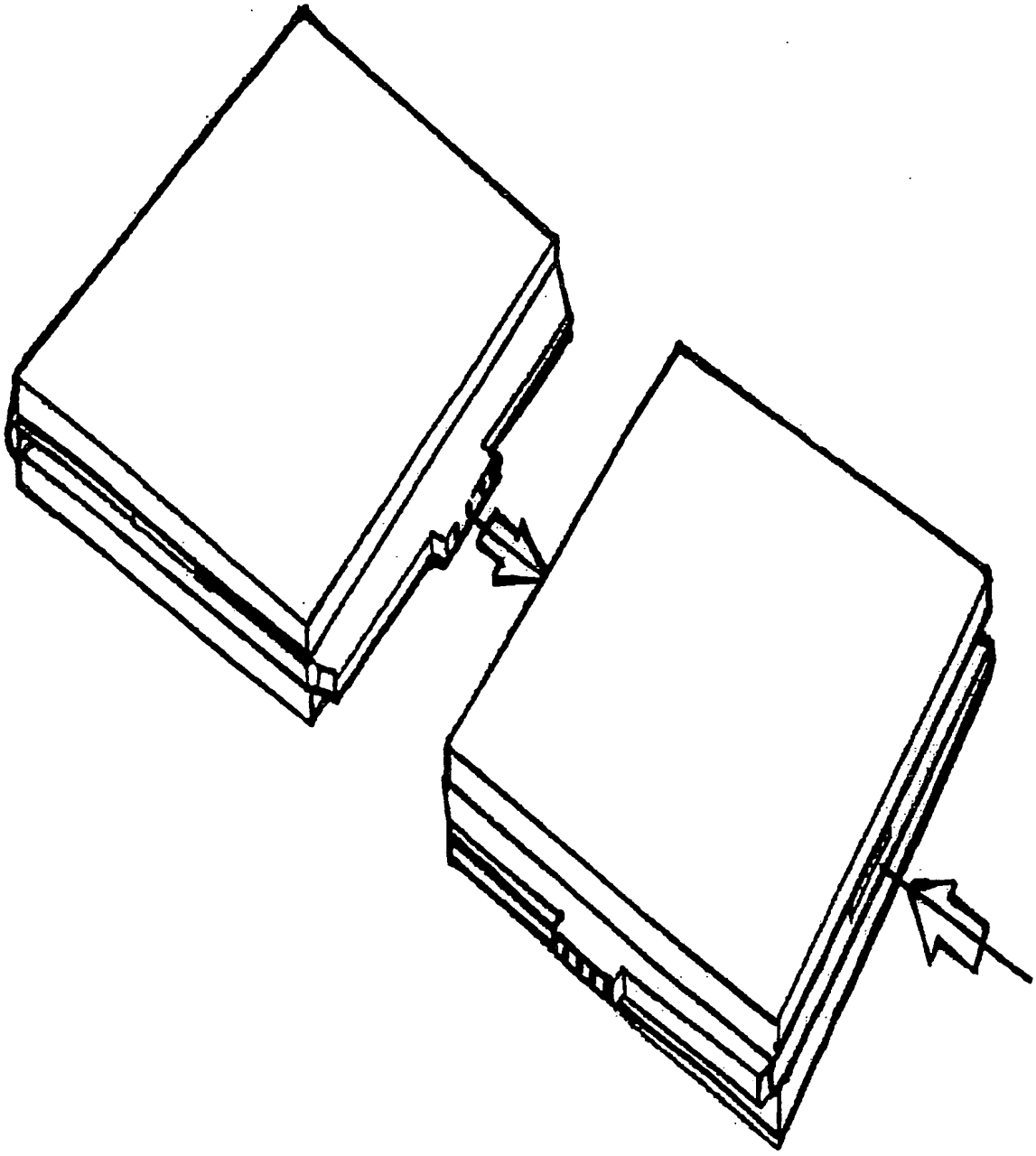

Fig. 9

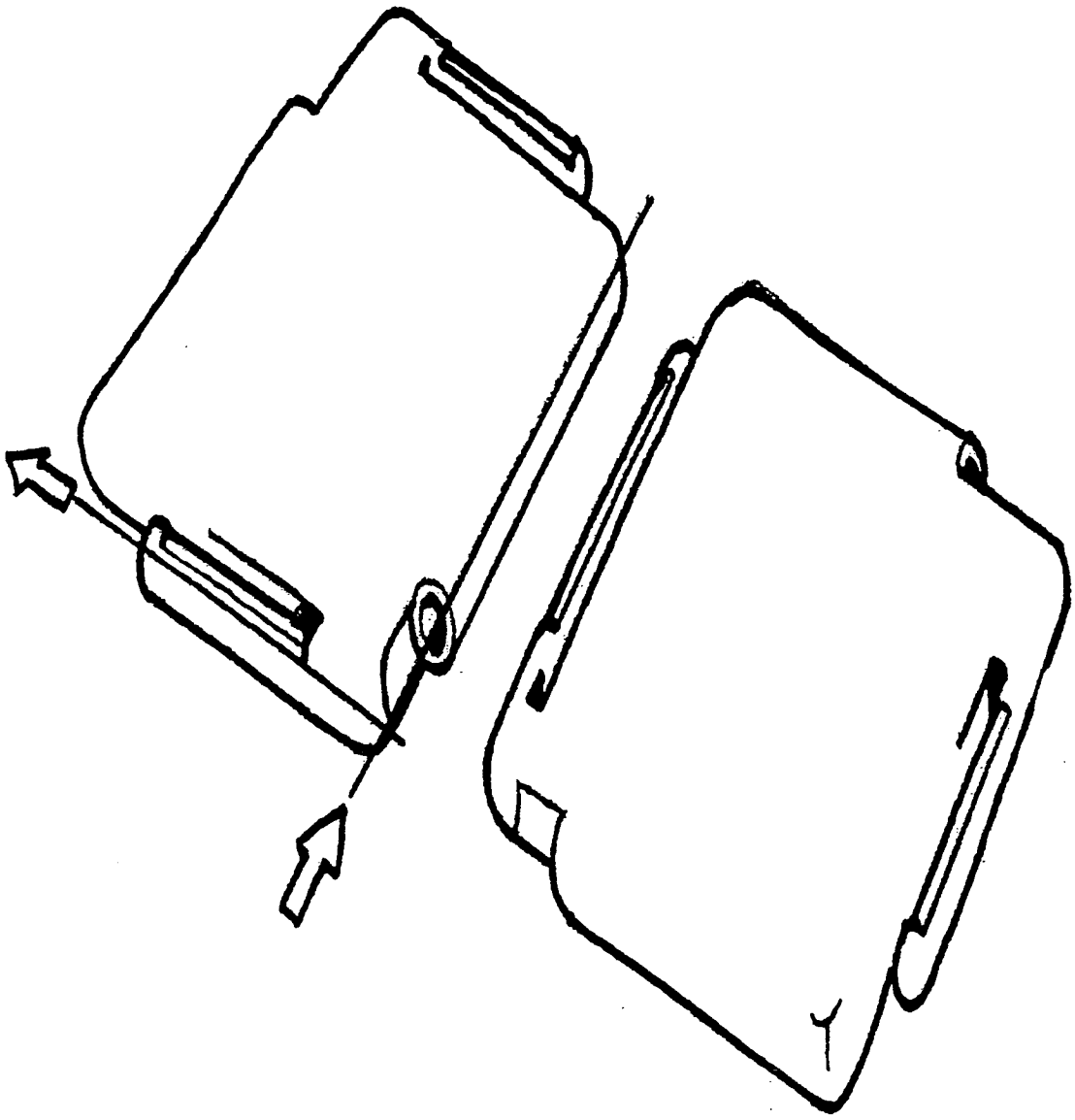

Fig. 10

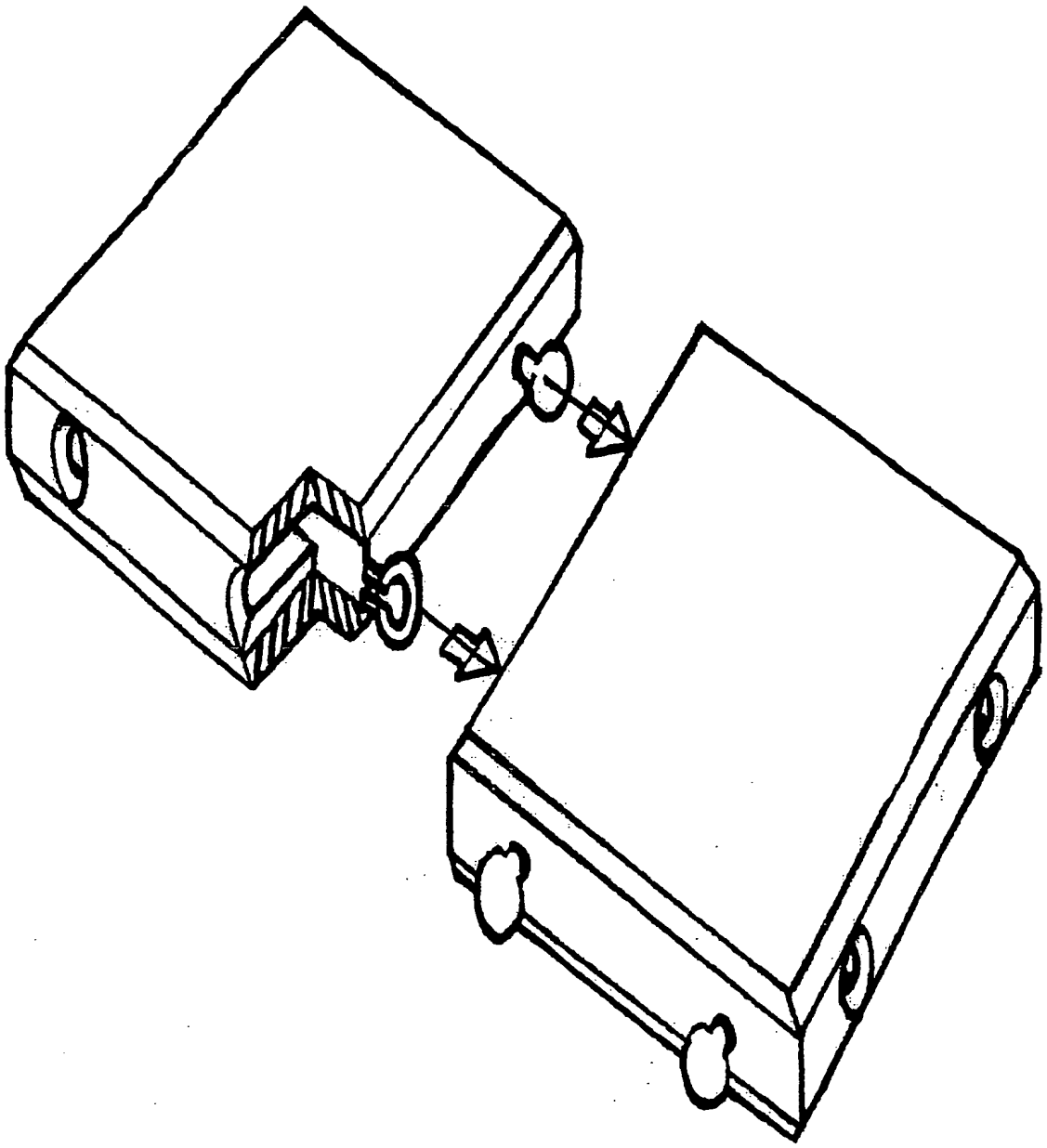

Fig. 11

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/GB 00/02063

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A63B24/00 A61B5/103

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A63B A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 40 21 240 A (BUHR MICHAEL DR ;SCHLUETER HENNING DIPL ING (DE)) 16 January 1992 (1992-01-16) column 2, line 26 -column 3, line 2 claims 1-16; figures	1-6, 15-17
A		11,12,14

X	DE 42 40 782 A (ROETHEL HILDEGARD ;ROETHEL OLIVER (DE)) 9 June 1994 (1994-06-09) claims 1,2,9,10	1-3
A		14

A	US 5 642 880 A (WISEMAN KATHERINE O ET AL) 1 July 1997 (1997-07-01) abstract; figures	1

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 September 2000	13/09/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Sedy, R

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/02063

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 04, 31 March 1998 (1998-03-31) -& JP 09 325674 A (COMBI CORP), 16 December 1997 (1997-12-16) abstract	5,7,8
A	DE 37 34 023 A (BRUNNER WOLFGANG ;ZECH LUDWIG VON (DE)) 27 April 1989 (1989-04-27) column 1, line 6 - line 11	9
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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int ional Application No
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